

drop from 50 hours a week early on to 15 hours by the time the station is able to house its full complement of seven people in 2003.

Space researchers design their experiments to run as autonomously as possible, because crew time is the scarcest commodity in orbit. But initially the station may seem like a step backward from Spacelab missions, where scientist 'payload specialists' were aboard just to do research (including almost all the Europeans, Japanese and Canadians who have flown to date). "I think people will be disappointed" in how little time the astronauts have for research as they build and troubleshoot their new home in orbit, says one veteran space experimenter. The research community has waged, and so far lost, a battle to have a payload specialist on the station exclusively for science.

John Blaha, a former NASA astronaut who spent four months on the Russian Mir space station in 1996, earns praise from scientists as a dedicated experiment operator who worked hard to deliver as much data as possible in orbit. Now an insurance executive in Texas, Blaha insists that "NASA needs to shift its culture" if it wants astronauts to do quality research on the space station.

Micromanaging the crew will not work on flights lasting several months, he says. Astronaut/experimenters should be well versed in the goals of a research project, but should then be left to operate an experiment on their own schedule. They also need to be able to talk direct to investigators on the ground when they run into a problem. If these guidelines aren't followed on the station, Blaha says flatly, "we won't be as efficient and we won't get as much done".

Will these and other warnings from scientists be heeded? The space research community, long accustomed to being second-class citizens in the world of 'piloted' spaceflight, can only hope for the best. One of the many ironies of the space station is that this most elaborate home ever built for people in space will be a less-than-ideal platform for doing the basic research needed to be able to send humans safely to Mars — ultimately its most convincing rationale.

The one piece of equipment SBRI director Laurence Young says he would want most for such research, a centrifuge big enough for humans, was thrown out long ago as too expensive. The station will contribute little knowledge about the threat from space radiation — some say the biggest biological hurdle facing Mars crews — because its orbit is protected from the most dangerous particles.

But the space station is a compromise, and no one will come away entirely happy — not the researchers, not the engineers working under great fiscal and institutional pressure, and not the politicians. They will get a station far less grand and more expensive than the one Ronald Reagan promised the world back in 1984. □

When astronauts refuse to volunteer

On next April's NeuroLab space shuttle mission, four scientist/astronauts have agreed voluntarily to insert tungsten needle electrodes into their legs to monitor nerve activity — all in the name of science.

Not all astronauts are so obliging. US crew members on the Russian Mir space station have in the past refused to perform even simple, non-invasive tasks simply because they didn't want to. It doesn't matter that the research has been peer reviewed and paid for, or that a scientist may have spent months, or even years, planning a test. By the rules of medical ethics and informed consent, an astronaut/test subject is free to just say no, and not give a reason.

For scientists who conduct human research in space, astronaut cooperation has become a troubling and sensitive issue, which they are loath to discuss on the record. "This is not just a theoretical problem," says one researcher who has had tests refused. It has happened more than once on Mir.

On Earth, the scientist would simply get another volunteer. In space, only six test subjects might be available for an entire research project. When an astronaut balks at having his or her blood drawn, there is no-one else to turn to, and the experiment is likely to be scrapped.

Most astronauts are willing participants in research, and many investigators — particularly those who have worked with 'payload specialists' flown specifically to conduct science — have only good experiences to report. But some astronauts take the research less seriously.

Scientists who need critical biomedical data from immediately before and after a spaceflight to compare with in-orbit results report that sometimes the measurements get done and sometimes they don't, depending on the individual astronauts.

Russian cosmonauts on Mir have presented a different problem — likely to crop up again with the space station — by demanding to be paid as test subjects. NASA has refused, arguing that its astronauts get no such bonuses. The data have gone uncollected.

Since the first crews on the space station will alternate between two Russians with one American and two Americans with one Russian, "a lot of anxiety is building up in the research community" over the availability of test subjects, says one scientist.

Career NASA astronauts have in the past been wary of scientists treating them as human guinea pigs. It can be more than just a matter of pride or privacy — the discovery of an unexpected cardiac arrhythmia or



Testing time: not all astronauts participate happily in research.

susceptibility to space sickness can ground astronauts or otherwise damage their careers. This has contributed to another tension, between academic biomedical researchers and the

doctors at NASA's Johnson Space Center in Houston who are responsible for crew health and safety. Outsiders complain that the NASA doctors have received preferential treatment in flying 'experiments' that aren't as rigorously peer reviewed.

Communication between the two camps is not always good. More than once, according to several sources, an outside researcher running a carefully controlled experiment in human physiological responses to spaceflight has had an experiment ruined or compromised after NASA doctors, in private conference with an astronaut/test subject, prescribed medicine (for example, for space sickness) without informing the researcher.

Discussion of these issues has reached a high as NASA administrator Dan Goldin, and several internal NASA committees and outside working groups have met to work out a compromise between astronauts' concerns about privacy and informed consent, and the needs of biomedical researchers. Since standards for medical ethics may vary among the space station's international partners, a Human Research Multilateral Review Board will also be established to set consensus guidelines for human research.

Ronald Merrell, the head of Yale University's department of surgery and chairman of NASA's advisory group for space flight medicine, believes the problems can be resolved, particularly if astronauts are treated as informed partners in conducting research. "You make it their project," he says.

Laurence Young, a researcher at the Massachusetts Institute of Technology who heads NASA's Space Biomedical Research Institute, agrees. Still, he says, space crews "have a privilege but also a responsibility", and part of their responsibility includes helping scientists to answer fundamental research questions that the station will be built, in part, to address.